Cloud Computing a Sustainable approach- Need of the hour for Green Computing.

Dr. Smita Shingrup

Asst. Professor, Dept. of Management
Smt. Maherbanu College of Science & Commerce, Akola (MS)

***Abstract*- The inception of the industrial revolution accelerated the exploitation of fossil-fuels and there by unknowingly polluting the atmosphere leading to higher carbon foot print and water foot print. It took quite a long time to realize the damage that is being done. It is our duty today to look upon environment friendly approaches for our sustainable future Invention, Innovation and Adaptation of green technologies is the need of the hour. With ever increasing usage of IT infrastructure around the globe, the increase in energy consumption and carbon emission is a worrisome situation for everyone because of its direct effect on environment. The environment is being dangerously impacted by Information Technology infrastructure's, extensive use and its waste. Cloud computing has emerged as one step further solution to deploy all virtualized IT resources as per need on self-service basis as a rental method for the users. This paper analyses about the various e waste produced and how cloud computing can be used for the reduction of hardware and ensure the safety of environment.**

***Keywords*- Cloud computing, carbon emission, energy consumption, IT waste, virtualization.**

1. INTRODUCTION

E waste management is one of the main issues faced by the IT industry. E waste management consists of both less production of e waste and the recycling of the produced ones. Accumulation of e- waste can lead to resource shortage and environmental pollution. Moreover it also makes sustainable development hard and the idea of greener IT industry impossible. The recycling of e waste also helps in lowering the cost of manufacture of products. Along with the current methods for recycling of the e waste produced, the rising trend of cloud computing can be used for e waste management. Cloud computing can help companies reduce their e-waste in several ways.

- First- companies no longer have to purchase, repair, or replace hardware for an on-site IT infrastructure when they sign up for cloud-based solutions. They will not have to dispose of all of their obsolete or broken servers, storage devices, networking hardware, and cables every year.
- Second- cloud hosting companies utilize hardware more efficiently. They can host multiple applications and infrastructures per server. As a result, cloud hosting providers purchase relatively small amounts of hardware and fully utilize their servers, storage devices, and networking hardware before disposing of them.
- Third-companies that adopt cloud-based solutions do not have to frequently repair or replace their end-user hardware such as desktops, laptops, keyboards, mouse, and monitors. The servers of the hosting company will take care of the majority of the processing and storage. Old devices will perform as well as brand-new hardware with cloud-based solutions. Businesses may not even have to purchase any new hardware; employees can also access cloud-hosted applications and infrastructures from their personal laptops, tablets, and smartphones. Unlike other revolutionary technologies, cloud computing does not require people to get rid of their old devices. Instead, the cloud revitalizes older computers and infrastructure hardware.

2. BASIC CONCEPTS

2.1. Electronic Waste

The e waste contains many lethal elements like lead & cadmium such as in cadmium batteries, cathode ray tubes with lead oxide & barium, brominated flame retardants which are used on printed circuit boards, cables and plastic casing; poly vinyl chloride (PVC) coated copper cables and plastic computer casings that discharge highly toxic dioxins& furans when burnt to obtain valuable metals. Mercury in flat screens, mercury switches, poly chlorinated biphenyl's (PCB's) present in older transformers, capacitors etc, also contribute to e waste production. The current method to reduce environmental hazard is hardware recycling which is based on the e- waste collection, dismantling and recovery of valuable components manually and final processing for metal recovery through various metallurgical process. This can help in the management of e-waste to certain extend but does not solve the problem of e waste completely. E-waste consists of more than 92% retrievable and reusable components, of which some are exceedingly precious and limited. Approximately, 50 million tons of e waste consists of 15 million tons of steel, 4 million tons of aluminum, 6 million tons of copper over & above glass, plastic, silver, gold, palladium, platinum, iridium etc. Because of high recycling costs in developed nations, 80% of e-scrap goes in land fill, in spite of being so resource rich[1]. And, the developing nations regrettably do not deploy environment friendly practices. As a result, both the sets of countries are equally spoiling the environment and creating environmental pollution. Computers contains lots of useful parts and modules that can be recycled, reused and re-purposed, that it's

1 Minimizing Electronic Waste using Infrastructure as a Service by Blessy Mathew, *International Journal of Computer Applications® (IJCA) International Conference on Emerging Technology Trends (ICETT) 2011* 7

a disgrace to merely throw them away. PC fans make great air filters, mother boards can become jewelry, hard drive platters skillfully turn into clocks and power supplies, and c.d. drives become domestic secret safes and roulette wheels.
The hazardous and toxic substances found in e-waste include.

- Lead (Pb) and cadmium (Cd) in printed circuit boards (PCBs).
- Lead is primarily found in all electronic products/ assembly, cathode ray tubes (CRT).
- Cadmium is found in monitor/ CRTs and computer batteries.
- Mercury is found in switches and flat screen monitors.
- Polychlorinated biphenyls are found in capacitors, transformers, printed circuit boards, plastic casings, cable and polyvinyl chloride (PVC) cable sheathing for insulation and PBD/PBDE in plastic parts of electronics.
- Apart from these materials, 36 chemicals are also being used in the manufacturing of these e-wasted equipment
- E-waste accounts for approximately 40 percent of the lead and 70 percent of heavy metals found in landfills.
- These pollutants lead to ground water and air pollution and soil acidification.

2.2 Data Centers

The most important and vulnerable component in computer system is a data center. It is a warehouse for the storage, management, and distribution of data. It acts as a server where the greater part of storage and enterprise servers are operated and managed. Data centers are energy-intensive facilities that support a diverse set of services such as Web, e-mail, data storage, and processing. They are operated around the clock, and are energy intensive. It has been reported that global data center emissions will grow 7% year-on-year through 2020.[2] Over the last decade India has witnessed increased demand in data because of explosive growth in smartphones and widespread use of social media apps, banking and e-commerce transactions, and multimedia storage needs, providing an impetus to the large growth in data center markets in India. According to studies, Indian data center spending on storage, server, and network equipment reached $3 billion by 2016.[3]Energy represents one of the most significant operating costs in data centers. Rising energy costs increase their operational expenses. In India, where coal is the primary source of electricity generation, it is necessary for data centers to adopt sustainable operations.

Fig 1: A Data center
Image source: www.google.com

3. GREEN COMPUTING

Green computing refers to the use of computers in an environmentally friendly way. With the increased use of technology, there is a need to develop energy-saving devices. The US Department of Energy and the Environmental Protection Agency in 1992 created the Energy Star Program. The purpose of the Energy Star Program is to encourage the development of energy-saving devices. Hardware that contains the Energy Star Logo exceeds the minimum federal standards for reduced energy consumption. In other words, green computing involves reducing the electricity and environmental waste while using a computer. Hardware devices should comply with the Energy Star program guidelines. It is encouraged that manufactures create energy-efficient devices.

Fig 2: Energy Star Logo

[2]https://www.theatlantic.com/technology/archive/2015/12/there-are-no-clean-clouds/420744/
[3]https://www.researchgate.net/profile/Rish_Ghatikar/publication/300197786_Data_Center_Energy_Efficiency_Standards_in_India/links/570da1ff08aed31341cf7c63/Data-Center-Energy-Efficiency-Standards-in-India.pdf

Image source: www.google.com

Some of the "Green Computing Suggestions" include-[4]

- Use computers and devices that comply with the Energy Star program
- Do not leave the computer running overnight
- Turn off the monitor, printer, and other devices when not in use
- Use LCD monitors instead of CRT monitors
- Use paperless methods to communicate
- Recycle paper
- Buy recycled paper
- Recycle toner cartridges
- Recycle old computers, printers and other devices
- Telecommute to save to save gas
- Use video conferencing and VoIP for meeting.

4 Situation of E-Waste in India [5]

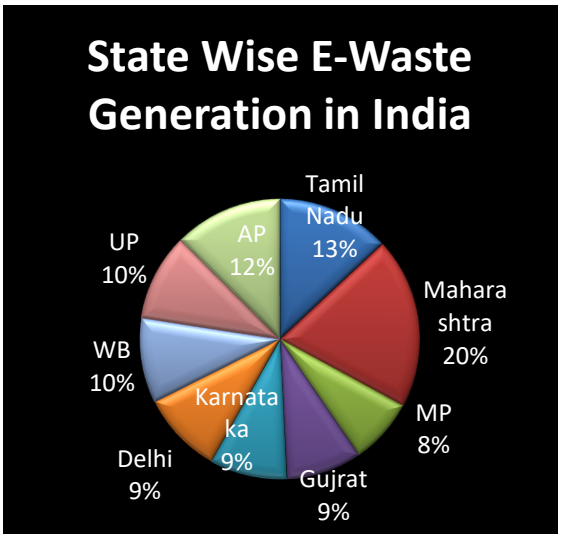

Fig 3
(State wise E-waste generation in India)

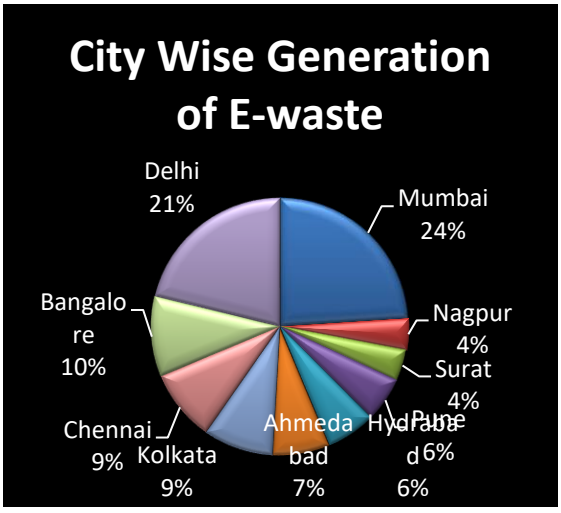

Fig 4
(City Wise generation of E-waste in India)

5 Ways to tackle E-Waste

[4]What is green computing?
www.wikipedia.com

[5] http://www.thehindubusinessline.com/info-tech/india-likely-to-generate-52-million-tonnes-of-ewaste-by-2020-study/article8686442.ece

Fig 5

6 Situation of Recycling in India

- India's production of e-waste is likely to increase by nearly three times, from the existing 18 lakh metric tons (MT) to 52 lakh MT) per annum by 2020.
- India banned e-waste imports in 2010, tens of thousands of tons still land in the country illegally every year.
- A mere 1.5% of India's total e-waste gets recycled due to poor infrastructure, legislation and framework.
- 23 recyclers have been registered for the treatment of e-waste produced in the country
- Over 95% of e-waste generated is managed by the unorganised sector and scrap dealers in this market.
- About 2/3s of e-waste workers in India suffer from respiratory ailments like breathing difficulties, irritation, coughing, choking, and tremors problems due to improper safeguards and dismantling workshops.
- about 5 lakhs child labourers between the age group of 10-14 are observed to be engaged in various e-waste activities, without adequate protection and safeguards.

7. Cloud Computing[6]

The phrase cloud computing means "a type of Internet-based computing," where different services such as servers, storage and applications are delivered to an organization's computers and devices through the Internet.

Your PC or device is simply what's connecting you to the cloud. Cloud computing is a type of computing that relies on sharing computing resources rather than having local servers or personal devices to handle applications. The cloud consists of several cloud providers like Amazon, Elastic Hosts, Google applications, etc. They provide the clients with their requirements. Here all the clients share the same cloud but each user has an impression of their own private hardware.

7.1 Architectural components

All cloud computing services fall into three basic categories such as infrastructure as a service (IaaS), platform as a service (PaaS) and software as a service (SaaS). These are sometimes called the cloud computing stack, because they build on top of one another. If you know the difference between what they are and how they are you can easily select any one of them according to your requirements.

(a) Infrastructure-as-a-service (IaaS)

This is the most basic category of cloud computing services. With IaaS, you can rent the IT infrastructure such as the servers, virtual machines (VMs), storage, networks, operating systems etc. from a cloud provider on a pay-as-you-go basis.

(b) Platform as a service (PaaS)

Platform-as-a-service (PaaS) refers to cloud computing services that supply an on-demand environment required for developing, testing, delivering and managing software applications. PaaS makes it easier for a developer to quickly build any web or mobile application, without getting worried for the setup and maintenance of the infrastructure such as servers, storage, network and databases needed for development, as they are readily available with PaaS.

[6] "cloud computing in everyday life"by Tushar S. Dhanokar, Compuman Tech 2017

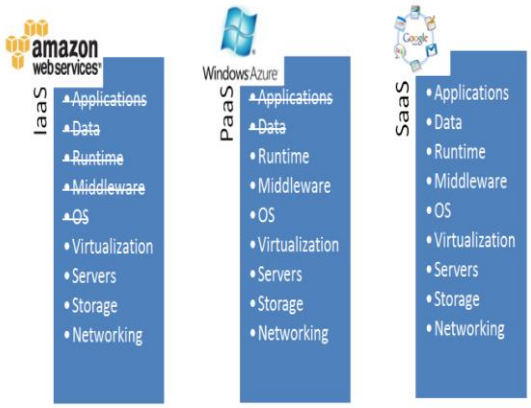

Fig 5: Example of Iaas vs Paas vs Saas
Image source: www.Linkedin.com

(c) Software as a service (SaaS)

Software-as-a-service (SaaS) is a software distribution model over the Internet, in which the applications are hosted on demand and typically on a subscription basis by a service provider. With SaaS, cloud providers handle any maintenance, like software upgrades and security patching. Users can connect to the application over the Internet, using a web browser on their mobile phone, laptops or PC.

7.2 Types of cloud deployments[7]

All cloud services are not similar thus enterprises and individuals must determine the hosting solution that best suits their requirements. Below is an outline of three different ways to deploy cloud computing services or resources as follows.

(a) Public cloud

Public cloud is nothing but what most people think when they hear about the term "cloud" and can simply be related to "storage" and

Fig 6: Features of various types of clouds.
Image source: www.bodhost.com

sometimes the computing resources such as servers. A public cloud is owned and operated by a third-party cloud service provider which includes the management and maintenance of all the necessary hardware, software and other supporting infrastructure. The user of a public cloud can access these services and manage their account using a web browser.

Examples of public cloud are: Amazon Cloud Drive, Google Drive, and Microsoft OneDrive

(b) Private cloud

The cloud computing resources which are exclusively used by a single business or organization can be referred to a Private cloud. A private cloud can be physically located on the company's on-site datacenter or some companies also pay third-party service providers to host their private cloud. The services and infrastructure are maintained on an individual network in a private cloud.

(c) Hybrid cloud

Hybrid clouds are a combination of public and private clouds which are combined together with the help of technology that allows the data and applications to be shared between them. Due to the easy exchange of data and applications between private and public clouds, hybrid cloud gives a business's greater flexibility and more deployment options.

[7] "cloud computing in everyday life"*by Tushar S. Dhanokar, Compuman Tech 2017*

8. Cloud computing is Green Computing

Cloud infrastructure addresses two critical elements of a green IT approach: energy efficiency and resource efficiency. Whether done in a private or public cloud configuration, as-a-service computing will be greener for the following four reasons.

8.1 Resource virtualization

- Virtualization is a rudimentary technology used in the deployment of cloud-based infrastructure. It allows one physical server to be able to run two or more operating system images simultaneously. By enabling this consolidation, virtualization of servers will lessen the footprint from physical servers, inherently contributing to the green initiative.
- From a resource-efficiency perspective, less equipment is needed to run workloads, which proactively reduces data center space and the eventual e-waste footprint. From an energy-efficiency perspective, with less physical equipment plugged in, a data center will consume less electricity.
- It's worth noting that server virtualization is the most widely adopted green IT project implemented or planned, at 90 percent of IT organizations globally into 2011.[8]

8.2 Automation software

- The presence of virtualization alone doesn't maximize energy and resource efficiencies. To rapidly provision, move, and scale workloads, cloud-based infrastructure relies on automation software.
- Combined with the right skills and operational and architectural standards, automation allows IT professionals to make the most of their cloud-based infrastructure investment by pushing the limits of traditional consolidation and utilization ratios.
- The higher these ratios are, the less physical infrastructure is needed, which in turn maximizes the energy and resource efficiencies from server virtualization.

8.3 Pay-per-use and self-service

- The pay-as-you-go nature of cloud-based infrastructure encourages users to only consume what they need and nothing more. Combined with self-service, life-cycle management will improve, since users can consume infrastructure resources only when they need it -- and "turn off" these resources with set expiration times.
- In concert, the pay-per-use and self-service capabilities of cloud-based infrastructure drive energy and resource efficiencies simultaneously, since users only consume the computing resources they need when they need it.

8.4 Multitenancy

- A multi-tenant setting allows many different businesses in a public cloud or many business units in a private cloud to use the same cloud-based infrastructure for their data loads.
- By combining demand patterns across many organizations and business units, the peaks and troughs of compute requirements flatten out. Combined with automation, the ratio between peak and average loads becomes smaller, which in turn reduces the need for extra infrastructure. The result: massive efficiencies and economies of scale in energy use and infrastructure resources.
- So migrating workloads to cloud resources, or developing new workloads in a cloud-native environment, can help an IT organization contribute to energy-efficiency and sustainability goal.

9. Benefits of using cloud services

9.1 Better Infrastructure

Public Cloud data centers are typically located closer to the facilities that power them to prevent large losses during the process of transmitting electrical energy over long distances. Traditional data centers usually don’t have a choice for location unless the company that builds it has tons of money, like Facebook or Yahoo. Cloud computing data centers also use less wattage to provide back-up power and cooling for their data centers due to superior hardware setup. These data centers are designed at scale and built for efficient energy use to achieve optimal utilization and temperature.

9.2 Higher Utilization Rate

conventionally, companies use their own private data centers, which means these companies, have low utilization rates due to equipment being purchased and set up in anticipation of server usage spikes. The cloud consolidates machine use, operating servers at high utilization rates, increasing efficiency. When hardware sits idle, it creates poor efficiency and has negative effects on the environment. However, public cloud servers tend to be 2 to 4 times more efficient than traditional data centers due to highly utilized infrastructure.[9]

9.3 Hardware Refresh Speed

Traditional Data Center hardware tends to be used for long amounts of time before an upgrade or replacement because of high costs and time spent upgrading servers. Since the hardware in a public cloud tends to have much higher utilization rates than traditional servers, it will most likely have a shorter lifecycle, prompting a faster refresh time. It’s also more cost efficient for public cloud servers to upgrade on a regular basis because new technology brings in better energy efficiency. The more energy efficient hardware is the more money the public cloud provider will save, which causes drastically less energy to be used in the long run.

9.4 Reduced Electricity Use

Traditional data hardware systems are high maintenance, requiring uninterruptible power supplies, cooling, and tons of electricity. Moving basic software programs to the cloud can save electricity immensely. A case study done by the Lawrence Berkeley National Laboratory, projects that moving business software such as email, CRM, and more (on a national scale) to the cloud can

[8] http://www.renewableenergyworld.com/ugc/articles/2015/01/4-reasons-why-cloud-computing-services-are-a-green-solution.html

save enough electricity each year to power Los Angeles for 12 months. This means the cloud would lower the total energy consumption of these software applications by 87%.[10]

9.5 Reduction in Climate Impact

Climate impact is greatly reduced by the clouds improvement in energy efficiency as a result of fewer carbon emissions. According to AWS, "the average corporate data center has a dirtier power mix than the typical large-scale cloud provider." AWS, in combination with other cloud providers, use a 28% less carbon-intense power mix.[11] This also affects climate control costs, since it is much more expensive to run machines at peak performance levels in perfect temperature levels. The cloud eliminates this wasteful spending due to the use of energy efficient equipment and fewer carbon emissions.

10. CONCLUSION

When considering going cloud, numerous quantifiable benefits come to mind, predominantly: cost savings, simplified management, ease of access, increased efficiencies and improved computing capabilities. Beyond these commonly denoted advantages is an inherent benefit that tends to be unremarked in the case of cloud adoption. **The green or eco-friendly, aspect of the cloud is one of the most overlooked**, multifaceted advantages of cloud computing. By pushing the limits of consolidation and utilization, cloud-based infrastructure minimizes the e-waste footprint upfront by requiring less physical equipment. **But what happens when this equipment reaches its end-of-life?** While all organizations dispose of their end-of-life IT equipment in some shape or form, e-waste policies have long been an afterthought and are the least mature IT asset life-cycle management process. Just because cloud minimizes e-waste upfront, don't assume those managing cloud-based infrastructure have policies to ensure e-waste is redeployed, resold, donated, or recycled. We can conclude by saying that while adopting any new technology we should find out if we are really in need of that? What are its environmental impact ? And how green is this new technology?

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